

## ***SHORT REPORT***

# **Magnetic resonance imaging of the thorax in the evaluation of asbestosis**

S.I. Bekkelund\*, U. Aasebø\*\*, C. Pierre-Jerome<sup>+</sup>, J. Holmboe<sup>++</sup>

*Magnetic resonance imaging of the thorax in the evaluation of asbestosis. S.I. Bekkelund, U. Aasebø, C. Pierre-Jerome, J. Holmboe. ©ERS Journals Ltd 1998.*

**ABSTRACT:** The purpose of the study was to evaluate the accuracy of magnetic resonance imaging (MRI) in detecting subclinical morphological changes caused by asbestos exposure.

Conventional chest radiographs according to the International Labour Organisation (ILO) categories 0–11 and spirometric data were compared with MRI in 17 men with mean ( $\pm 2SD$ ) asbestos exposure time of  $24.6 \pm 13.0$  yrs. Mean age was  $62.0 \pm 9.4$  yrs. The inclusion criterion was an ILO score of 2 or more. Electrocardiographic registrations and antirespiratory movement artefact techniques were used in all MRI examinations to avoid movement artefacts.

Mean ILO grading was found to be  $7.7 \pm 3.8$  on chest radiography and  $9.8 \pm 2.0$  with MRI ( $p=0.01$ ). Five patients had a higher ILO stage as evaluated by MRI, but in nine patients the staging remained unchanged. MRI revealed mediastinal adenopathy in four patients. Forced expiratory volume in one second (expressed as a percentage of the predicted value) was negatively correlated with ILO score as assessed by MRI ( $r=-0.4$ ,  $p=0.032$ ).

Magnetic resonance imaging seems to be more sensitive than conventional radiographs in detecting subclinical fibrosis as well as the extent of pleural asbestosis.

*Eur Respir J 1998; 11: 194–197.*

\*Stakkevollan Occupational Health Centre, \*\*Dept of Internal Medicine, University Hospital, and <sup>+</sup>Dept of Rheumatology, University Hospital, Tromsø, <sup>++</sup>Centre for Lung Diseases, Harstad, Norway.

Correspondence: S.I. Bekkelund  
Stakkevollan Occupational Health Centre  
Stakkevollveien 27  
N-9019 Tromsø  
Norway  
Fax: 00 47 77627074

Keywords: Asbestosis  
magnetic resonance imaging  
occupational medicine  
pleural plaque

Received: May 2 1996  
Accepted after revision September 26 1997

Pleural plaques and diffuse pleural thickening and pulmonary fibrosis are common manifestations of asbestos exposure [1, 2]. Usually, the degree of asbestosis is evaluated using conventional chest radiographs [3, 4]. Cumulative asbestos exposure over time increases the prevalence of pleural changes and parenchymal asbestos-related changes [5]. Pulmonary fibrosis due to asbestos exposure, as well as pleural plaques, may be even more difficult to show at an early stage on plain radiographs [6], and pulmonary function tests are, therefore, needed to supplement radiographic examinations for higher accuracy [7]. Computed tomography (CT), however, is superior to radiography in detecting asbestos related pleural changes [8, 9].

To our knowledge, a comparative study of magnetic resonance imaging (MRI) and plain radiograph in evaluation of asbestosis has not been reported before. The object of this investigation was to determine whether MRI could give additional information to conventional chest radiography on the extent of subclinical asbestos-related, pleural changes and pulmonary fibrosis. Since the International Labour Organisation (ILO) grading system for asbestos diagnosis [4] was developed to reduce the inter-observer variation in reporting asbestos-related changes recorded from chest radiographs [9–10], we chose this system as a scoring method in both imaging modalities. Thus, we also introduce the ILO grading system for MRI.

## **Methods**

All patients with known asbestosis registered as out-patients in the pulmonary department at the Tromsø University Hospital were asked to participate in the study. Twenty males with a mean ( $2 \pm SD$ ) asbestos exposure time of  $24.5 \pm 13.9$  yrs were included in the study. The mean age was  $62.0 \pm 9.4$  yrs. The participants had been exposed to asbestos at work as mechanics, carpenters or fishermen. All participants had previously been exposed to asbestos in more than one profession. A combination of being a fisherman and mechanics is common in this geographic area (North Norway). Fifteen were smokers. The criteria for inclusion were as follows: 1) asbestos exposure; 2) asbestos related changes on chest radiographs; and 3) ILO score of 2 or more on chest radiographs. We used the ILO grading system categorized from 0 (0/-) to 11 (3/4) [4] and spirometry.

Pulmonary function tests included forced vital capacity (FVC) and, forced expiratory volume in one second (FEV<sub>1</sub>) by means of Flowscreen spirometer (Jaeger, Germany). Patients with known pulmonary pathology from other aetiology or systemic disease were excluded from the study. The following scheme for evaluating pleural plaques were used: ILO category 0 = no options; ILO category 1 = less than 2 opacities; ILO category 2 = more than 1 opacity; ILO category 3 = more than 2 opacities. Lung markings are obscured by opacities.

Table 1. – International Labour Organization (ILO) scoring system

Opacities Score	ILO category											
	0			1			2			3		
	0/-	0/0	0/1	1/0	1/1	1/2	2/1	2/2	2/3	3/2	3/3	3/4
	0	1	2	3	4	5	6	7	8	9	10	11

The subdivision of the categories is performed according to ILO [4]. Category 0/1 means 0 is the major category, while 1 is the alternative category.

To classify the parenchymal lesions we divided each category into three subgroups to provide a scoring system (table 1).

Axial images were acquired with spin echo T2-weighted (repetition time (TR)/echo time (TE) = 2181/30/100) and T1-weighted (100/21) sequences before and after injection of intravenous contrast (Gadolinium). The slice thickness/gap was 8.0/1.0 mm. We used a matrix of 176×256, with two signal averages and a field of view of 400 mm. Three patients were excluded, one due to claustrophobia, one due to dyspnoea and one due to obesity. The chest radiographs (posterior-anterior and lateral views) were interpreted independently by three physicians and classified into the ILO categories. The MRI examinations were interpreted by one radiologist, one pulmonary physician and one occupational physician. The qualitative data were recorded as a result of an agreement between the three physicians, while the quantitative parameters were recorded as the mean of three independent evaluations. The quantitative parameters included distribution of pleural plaques according to the ILO criteria, both for radiographic and MRI examinations. The qualitative findings searched for in the study included fibrosis, mediastinal adenopathy and additional findings.

Electrocardiographic registrations were performed continuously in all patients throughout the MRI examinations to avoid movement artefacts; thereby standardizing the procedure. The MRI was only performed during diastole. The radiographic and spirometric data were compared with the information obtained from the MRI.

The ILO score obtained from radiographic and MRI, as well as lung physiology parameters, are presented as mean±2SD. To compare the ILO score from the two imaging

modalities we used one-sided Student's t-test. Simple regression analyses and correlation coefficients were used to study the associations between variables. A p-value of less than 0.05 was considered significant.

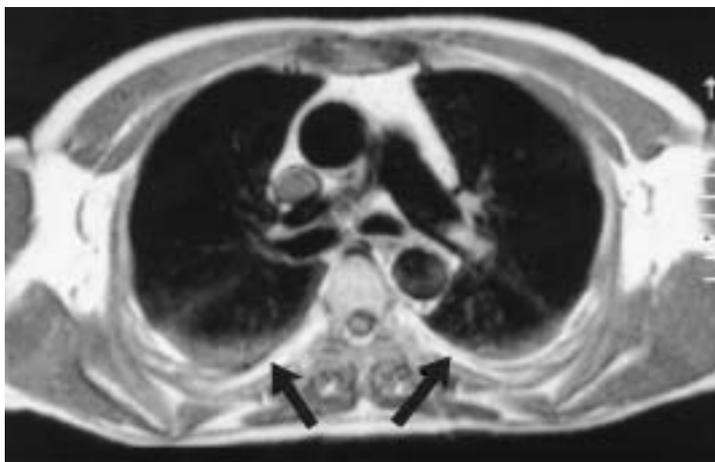
## Results

The distribution of the asbestos plaques was better appreciated on MRI (figs. 1a and 2a) compared to plain radiographs (figs. 1b and 2b). The plaques appeared hyperintense on both T1 and T2 weighted slices. The images acquired after injection of contrast (Gadolinium) showed no difference in the signal intensity of the pleural lesions. Both axial and coronal MRI better displayed the extension of interstitial fibrosis (figs. 2a and 3a). Parahilar adenopathies not detectable on conventional radiographs were identified on MRI slices (fig. 3a). In one patient, the coronal MRI revealed a well-defined mass in the left lung consistent with round atelectasis (fig. 3a), not visualized on the chest radiograph (fig. 3b).

Lung function studies in the whole group and in subgroups with fibrosis diagnosed on radiography and MRI are shown in table 2. Mean ILO score evaluated by radiography was 7.7±3.8 compared with 9.8±2.0 using MRI as the diagnostic tool (p=0.01). Five subjects (33%) had fibrosis according to radiography, and 13 (87%) when evaluated by MRI. Nine subjects (45%) had a higher ILO score when the number and distribution of plaques were assessed by MRI. No study subject was scored lower on ILO using MRI compared to ILO from radiograph.

A significant negative correlation was found between ILO score on MRI and FEV<sub>1</sub> percentage predicted (r=-0.4,

a)



b)



Fig. 1. – a) Magnetic resonance T1-weighted image demonstrating bilateral linear hyperintense plaques (arrows). b) Chest radiograph in the same patient, showing pleural plaques on both sides of the thorax and some degree of parenchymal involvement.

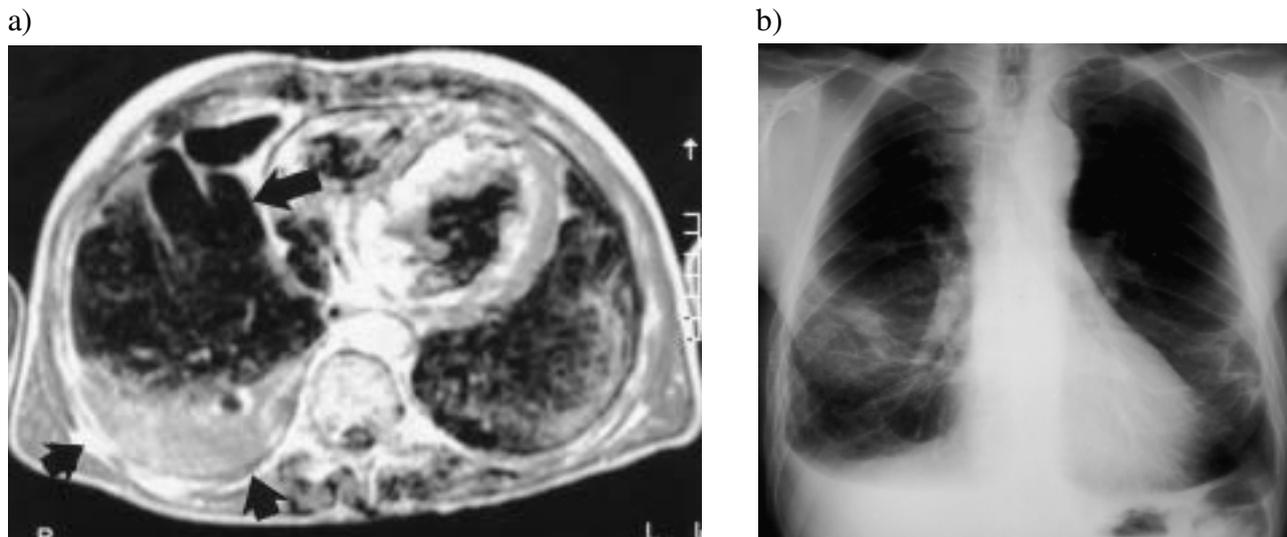


Fig. 2. – a) Magnetic resonance axial T1-weighted image. There is diffuse, bilateral interstitial fibrosis. The emphysematous bullae are located anteriorly (arrows) on the right. Note the hyperintense plaques on the right (short arrows). b) Chest radiograph in the same patient showing bilateral interstitial and pleural fibrosis on both sides. Also pleural plaques and parenchyma bands are visible as well as an emphysematous bullae and effusions on the right side.

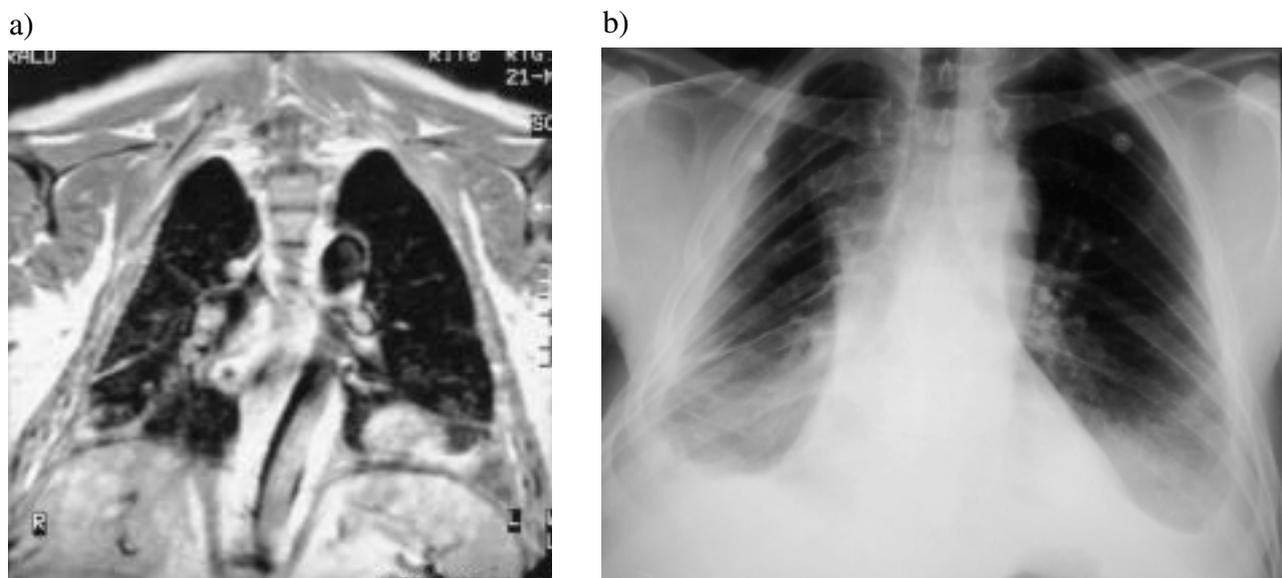


Fig. 3. – a) Magnetic resonance T1-weighted coronal image displaying a well-defined pulmonary mass (round atelectasis) on the left. b) Chest radiograph in the same patient (advanced stage) showing bilateral fibrotic changes and pleural effusions.

Table 2. – Lung function studies in asbestosis. A comparison between fibrosis diagnosed by radiograph and magnetic resonance imaging (MRI)

	Fibrosis		Without fibrosis	Total
	Radiograph	MRI		
Subjects n	5	13	7	20
FVC % pred	71.2±35.3	93.6±26.2	82.5±27.1	89.7±26.3
FEV1 % pred	64.6±30.1	88.2±24.8	75.2±29.6	83.7±26.6
FEV1 %FVC	72.0±15.0	87.9±25.3	69.1±12.8	81.3±23.2

Values are presented as mean±2SD. FVC: forced vital capacity; FEV1: forced expiratory volume in one second; % pred: percentage of predicted value; % FVC: percentage of FVC.

$p=0.032$ ), but not for other lung function parameters. No association was detected for ILO score (radiograph) and lung function. There was a positive correlation between the number of years of asbestos exposure and ILO score (radiograph) ( $r=0.56$ ,  $p=0.016$ ), but not for ILO score using MRI. Age was not associated with lung function parameters or radiographic findings. There was no evidence of increased pathology in the smokers.

### Discussion

This study shows that MRI is more sensitive than conventional radiography in early detection of asbestosis by showing increased occurrence of pleural plaques and

fibrosis as well as detecting a round atelectasis that was not visible on the radiograph. Furthermore, we suggest that the well-established ILO grading system based on radiography may be used as a method to compare radiography and MRI in the diagnosis of asbestosis.

Postero-anterior and lateral chest radiographs are routinely used to detect asbestos-related lesions in the pleura and in the lung parenchyma [12]. However, high resolution CT scans have proved to be more accurate than conventional radiographs in showing the asbestos-induced damages to the pleura and pulmonary parenchyma [8, 9, 13]. We did not perform CT scans to study the differences in sensitivity and specificity in diagnosing asbestosis between the two modalities, which is a limitation of this study. The role of MRI in the diagnosis of asbestosis is not sufficiently documented. MRI may be superior to CT in detecting pleural fluid by increasing the signal intensity [14], but reports on MRI in characterizing the distribution of pleural lesions are sparse. The spatial resolution and multiplanar capacity of MRI makes it superior to plain radiographs, as the distribution of the pleural plaques, interstitial fibrosis and emphysematous changes were better appreciated in axial and coronal slices in this study.

We found a negative association between increased ILO score on MRI and FEV<sub>1</sub> % pred. The negative correlation between FEV<sub>1</sub> % pred and MRI-ILO score but not for radiographic ILO score may indicate that MRI is a sensitive tool in detecting even subclinical asbestos-related lung impairment.

Previous studies have shown MRI to be useful in the evaluation of malignant mesothelioma [15, 16]. To our knowledge, this is the first description of asbestos related pulmonary changes by means of MRI. However, the limited number of patients and the lack of comparison with high-resolution CT images constitute drawbacks in this study. We failed to show interlobular septal thickening, parenchymal bands and honeycombing which are identified on CT. We may speculate, however, that MRI has a higher sensitivity than CT in detecting pleural plaques and mediastinal changes. Using contrast, pleural effusion may be even better visualized and thereby be introduced as an important tool in detecting early malignant diseases.

In conclusion, magnetic resonance imaging seems to be more sensitive than conventional radiographs in displaying subclinical fibrosis as well as demonstrating the degree of pleural plaques. Using magnetic resonance imaging we might expect a more accurate diagnosis. It remains to be investigated whether magnetic resonance imaging is superior to high-resolution computed tomography.

## References

1. Bateman ED, Benatar SR. Asbestos-induced diseases: clinical perspectives. *Q J Med* 1987; 47: 292–297.
2. Mossman BT, Gee JBL. Asbestos-related diseases. *N Engl J Med* 1989; 320: 1721–1730.
3. Selikoff IJ, Lilis R, Levin G. Asbestotic radiological abnormalities among United States merchant marina seamen. *Br J Ind Med* 1990; 47: 292–297.
4. International Labour Office. Guidelines for the use of the ILO international classification of radiographs of pneumoconiosis, revised edition. International Labour Office Occupational Safety and Health series (revised 1980). Geneva, Switzerland, International Labour Office. 1989; No. 22.
5. Nicholson WJ, Perkel G, Selikoff IJ. Occupational exposure to asbestos: population at risk and projected mortality 1980–2030. *Am J Ind Med* 1982; 3: 259–311.
6. Epler GR, McCloud TC, Gansler EA, Mikus JP, Carrington CB. Normal chest roentgenograms in chronic diffuse infiltrative lung disease. *N Engl J Med* 1978; 298: 934–939.
7. Becklake MR, Fournier-Massey G, McDonald JC, Siemiatycki J, Rossiter C. Lung function in relation to radiographic changes in Quebec asbestos workers. *Bull Eur Physiopathol Respir* 1970; 6: 637–643.
8. Begin R, Ostiguy G, Filion R, Colman N, Bertrand P. Computed tomography in the early detection of asbestosis. *Br J Ind Med* 1993; 50: 689–698.
9. Jarad NA, Wilkinson P, Pearson MC, Rudd RM. A new high resolution computed tomography scoring system for pulmonary fibrosis, pleural disease, and emphysema in patients with asbestos related disease. *Br J Ind Med* 1992; 49: 73–84.
10. Parker DL, Bender AP, Hankinson S, Aeppli D. Public health implications of the variability in the interpretation of "B" readings for pleural changes. *J Occup Med* 1989; 31: 644–647.
11. Ducatman AM, Yang W, Forman SA "B-readers" and asbestos medical surveillance. *J Occup Med* 1988; 30: 644–647.
12. Mossman BT, Gee JB. Asbestos-related diseases. *N Engl J Med* 1989; 320: 1721–1730.
13. Schmutz GR, Fisch-Ponsot C, Regent D, Sylvestre J. Computed tomography (CT) and magnetic resonance imaging (MRI) of pleural masses. *Crit Rev Diagnost Imag* 1993; 34: 309–383.
14. Davis SD, Henschke CI, Yankelevitz DF, Cahill PT, Yi Y. MR imaging of pleural effusions. *J Comput Assist Tomogr* 1990; 14: 192–198.
15. Muller N. Imaging the pleura. *Radiology* 1993; 186: 287–309.
16. Lorigan JG, Libshitz HI. MR imaging of malignant pleural mesothelioma. *J Comput Assist Tomogr* 1989; 13: 617–620.